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ABSTRACT

The N=1 analysis differs from a typical analysis of variance in that there is no within-cell error term. Thus interaction terms are used as estimates of error variance. If the interaction term in question represents a significant interaction, the F tests will be conservative. Tukey's test for nonadditivity will detect a common form of interaction. Listed in this paper is a computer program to calculate the N=1 analysis of variance and the necessary tests for nonadditivity. (Author)

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AOVN1:

DISCUSSION AND LISTING OF

A COMPUTER PROGRAM

FOR THE ANALYSIS OF VARIANCE

IN THE N=1 CASE

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Abstract

The N=1 analysis differs from a typical analysis of variance in that there is no within cell error term. Thus interaction terms are used as estimates of error variance. If the interaction term in question represents a significant interaction, the F tests will be conservative. Tukey's test for nonadditivity will detect a common form of interaction. Listed in this paper is a computer program to calculate the N=1 analysis of variance and the necessary tests for nonadditivity.

TM 840 050

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1. INTRODUCTION

This article presents a computer program, AOVN1, which will perform an analysis of variance for N = 1 designs, either factorial or with repeated measures. AOVN1 prints a standard AOV summary table, computing F values using the appropriate (assuming the fixed effects model) interaction mean square as the denominator for both repeated measure factors and non-repeated measure factors. The program provides the associated probability values. Tukey's test is performed for all interactions that are used as estimates of error variance and means for all effects are produced.

2. STATISTICAL DISCUSSION

The N = 1 analysis differs from a typical analysis of variance in that there is no within cell error term. Therefore, the highest order interaction must be used as an estimate of error variance. If this interaction is significant, the F tests with this denominator will be conservative. Thus, the researcher may benefit from insight into the nature of the interaction he is using for an error term. Tukey's test for nonadditivity will detect a common form of interaction (see Myers). AOVN1 performs Tukey's test on all interactions that are used as estimates of error variance.

3. CALCULATION PROCEDURE

The procedure given by Hartley is used for the basic analysis of variance. Tukey's test for nonadditivity is computed for the proper order interaction using the standard formula given by KIRK, page 228.

For the analysis of variance, F values are computed for the fixed effects model.

4. USAGE INSTRUCTIONS

AOVN1 may be used to analyze multifactor experiements having repeated measures for some, or none, but not all factors. F ratios are calculated for the fixed effects model. Cells should be estimated if observations are missing. The design must, of course, be at least a two-way design with at least one non-repeated measure, since interaction terms are used as an estimate of error variance.

SIZE RESTRICTIONS

a) No more than 8 factors

b) No more than 3000 cells (data values)

c) At least 2 factors

d) At least 1 non-repeated measure factor. With 1 non-repeated measure factor there will be an error term for the repeated factor F-test, but none to test the non-repeated factor.

CONTROL CARDS

TITLE CARD Cols 1-80	Any desired information may be entered. The program prints these 80 columns before and immediately following the analysis of variance.
LEVELS CARD Cols 1-80	Levels of factors in 3 column fields. When a number is less than 3 digits, fill out the field will leading (on the left) blanks. The factor levels are entered in the following order:
FIRST	Levels of non-repeated factors in consecutive fields, slowest - changing factor first. (see section on data order).
SECOND	One blank field.

THIRD	Levels of the repeated measure factors in consecutive fields, slowest - changing repeated measure factor first, and fastest - changing factor last (again, see section on data order). Omit if there are no repeated measures.
FORMAT CARD	
Cols 1-80	Fortran FORMAT statement, including parentheses, without the word "FORMAT". You may begin in column 1. The statement is used to describe the data cards.
THATSALL CARD	Place this card after the last data deck to terminate the program.
Cols 1-8	"THATSALL"

DATA ORDER

The program refers to the factors by assigning them consecutive alphabetic characters beginning with "A". The first variable listed on the LEVELS card will be "A", the second will be "B", etc. The data cards must be in the order consistent with the LEVELS card. That is, the levels of factor A vary slowest, factor B varies next slowest, etc. so that the last factor varies fastest. Note that any repeated measure factor will vary faster than any non-repeated factor. For example, consider a 2 x 2 x 2 design. The data should be sorted so that the cells are in this order: A1 B1 C1, A1 B1 C2, A1 B2 C1, A1 B2 C2, A2 B1 C1, A2 B1 C2, A2 B2 C1, A2 B2 C2.

DECK SETUP

The cards necessary for a single analysis are (not including system control cards, which will vary depending on the equipment and software used):

TITLE CARD

LEVELS CARD

FORMAT CARD

DATA CARDS

THATS ALL CARD

If a second analysis on different data is to be done, the following order will be used:

first TITLE card

first LEVELS card

first FORMAT card

first data deck

second TITLE card

second LEVELS card

second FORMAT card

second data deck

TTATSALL CARD

5. SAMPLE PROBLEM

The data for a 3 x 3 x 2 design to be analyzed is given in Table I. The control cards and data used to run the problem are shown in Figure I. The output consists of the AOV summary table, then the Tukey's Tests for all interactions, and finally all means. The means are printed in the same order that the data was entered in. For example, the AB means are in the order A1 B1, A1 B2, A1 B3, A2 B1, A2 B2, A2 B3, A3 B1, A3 B2, A3 B3.

TABLE I. A and B are groups, C a repeated measure.

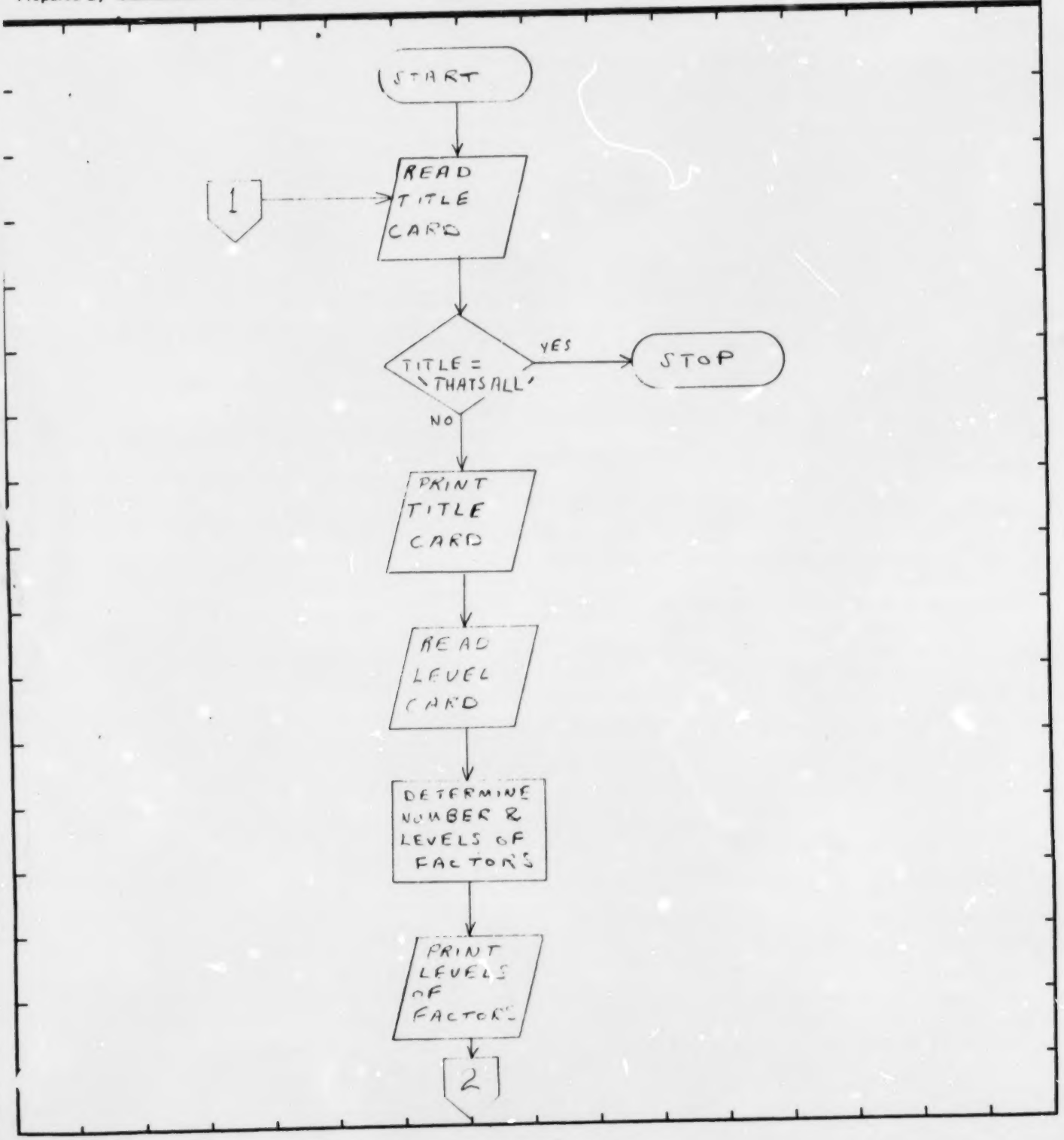
	B1		B2		B3	
	C1	C2	C1	C2	C1	C2
A1	4	6	2	2	3	4
A2	5	3	6	1	2	2
A3	2	4	4	2	3	5

FIGURE I. Control cards and data for sample problem.

6. FLOW CHART

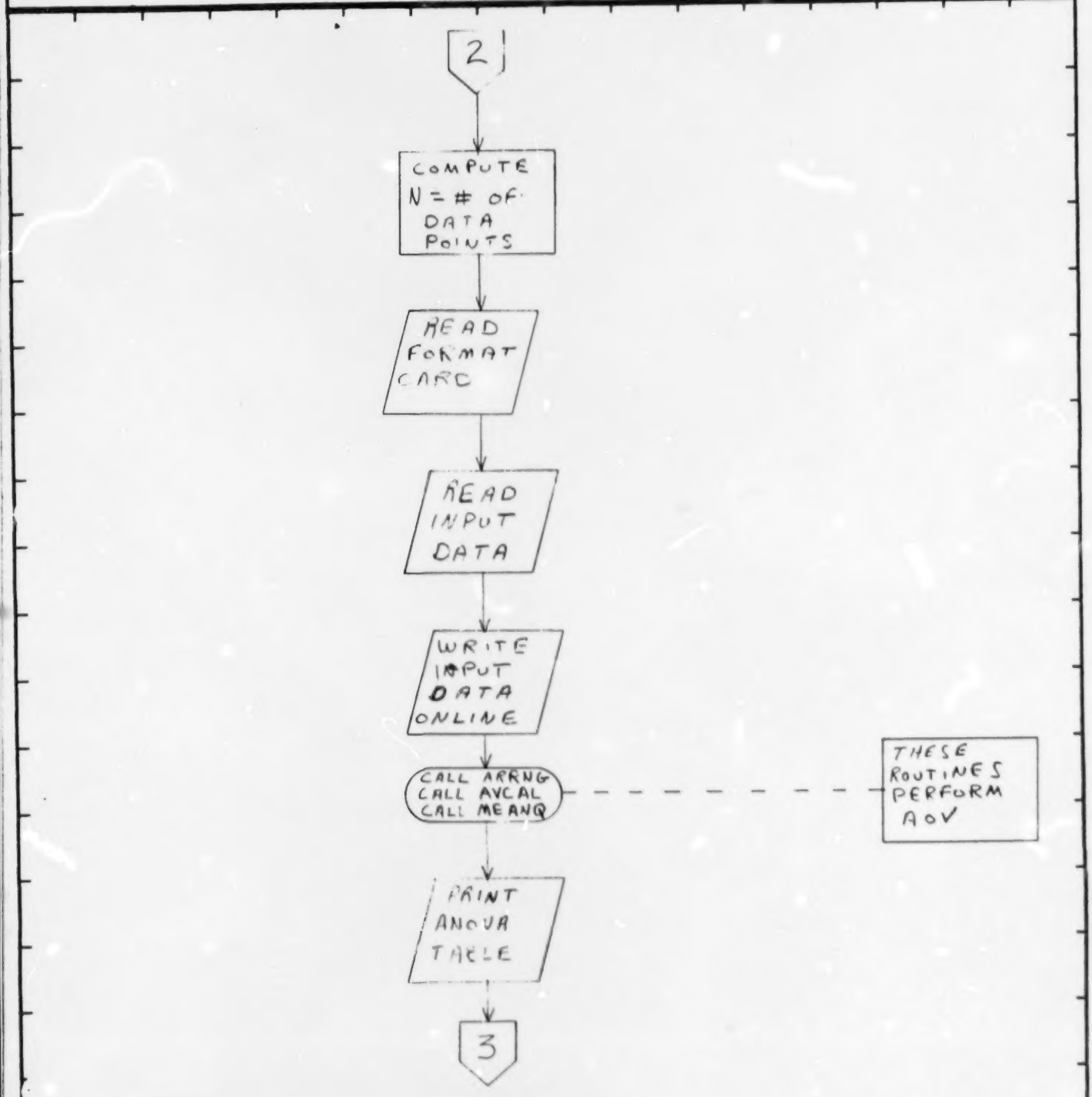
Project Leader DAVE TRITCHLER System/Job/Program Name AOVN1

Prepared By DAVE TRITCHLER Date 1 1 Page 1 of 3



. roject Leader _____ System/Job/Program Name AOVN1

Prepared By _____ Date 1 1 Page 2 of 3



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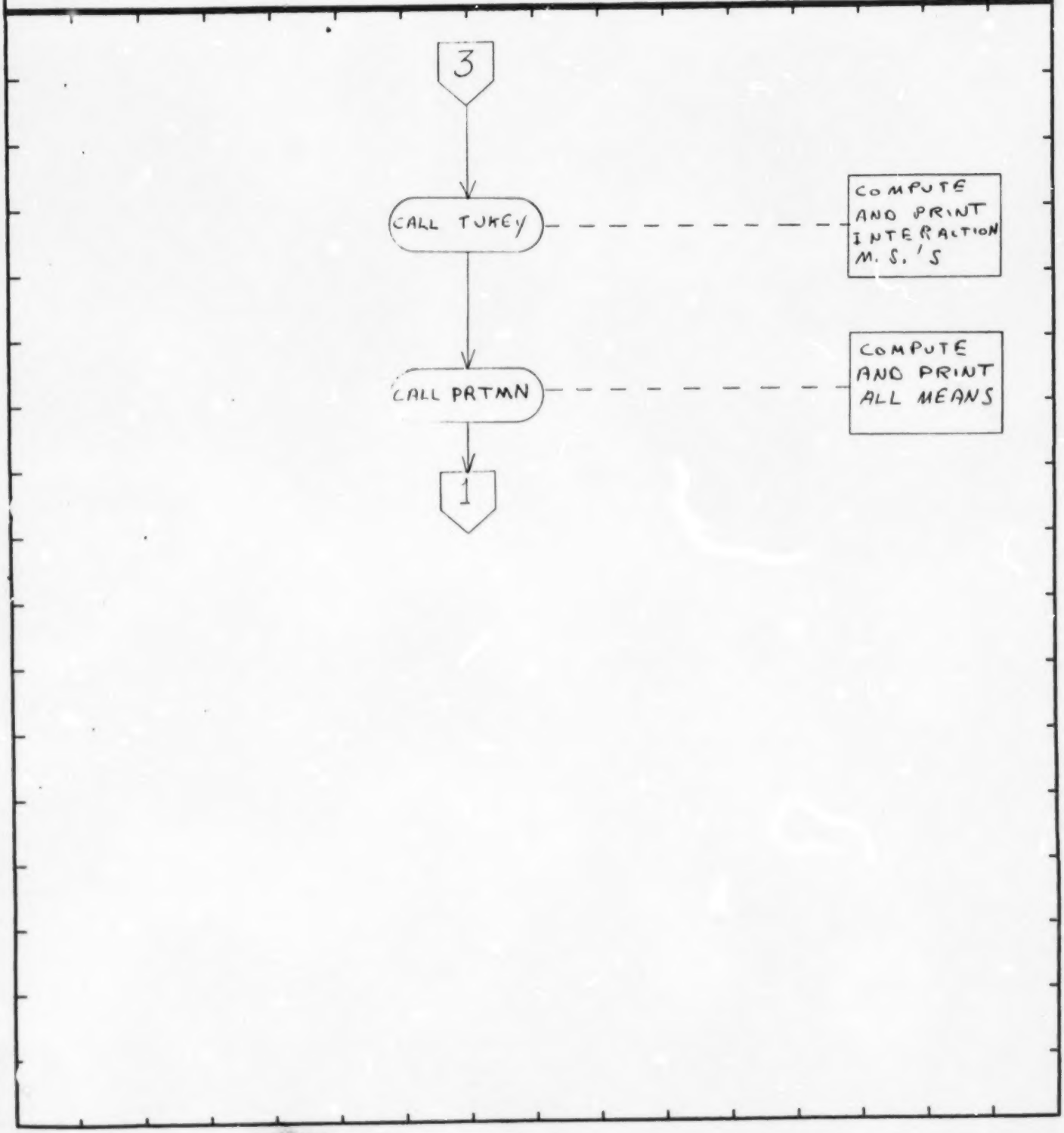

Project Leader DAVE TRITCHLER System/Job/Program Name ARRNG

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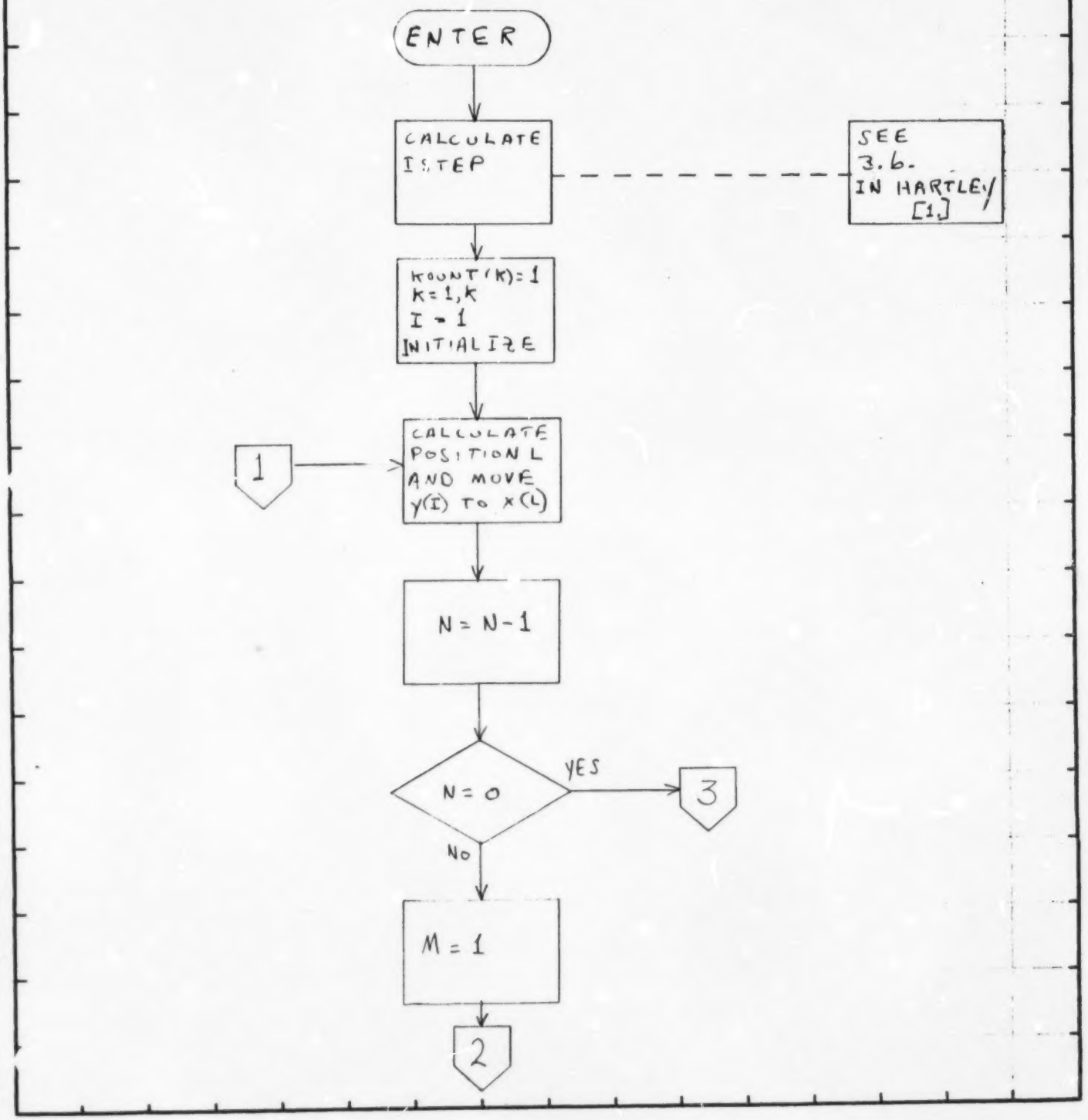
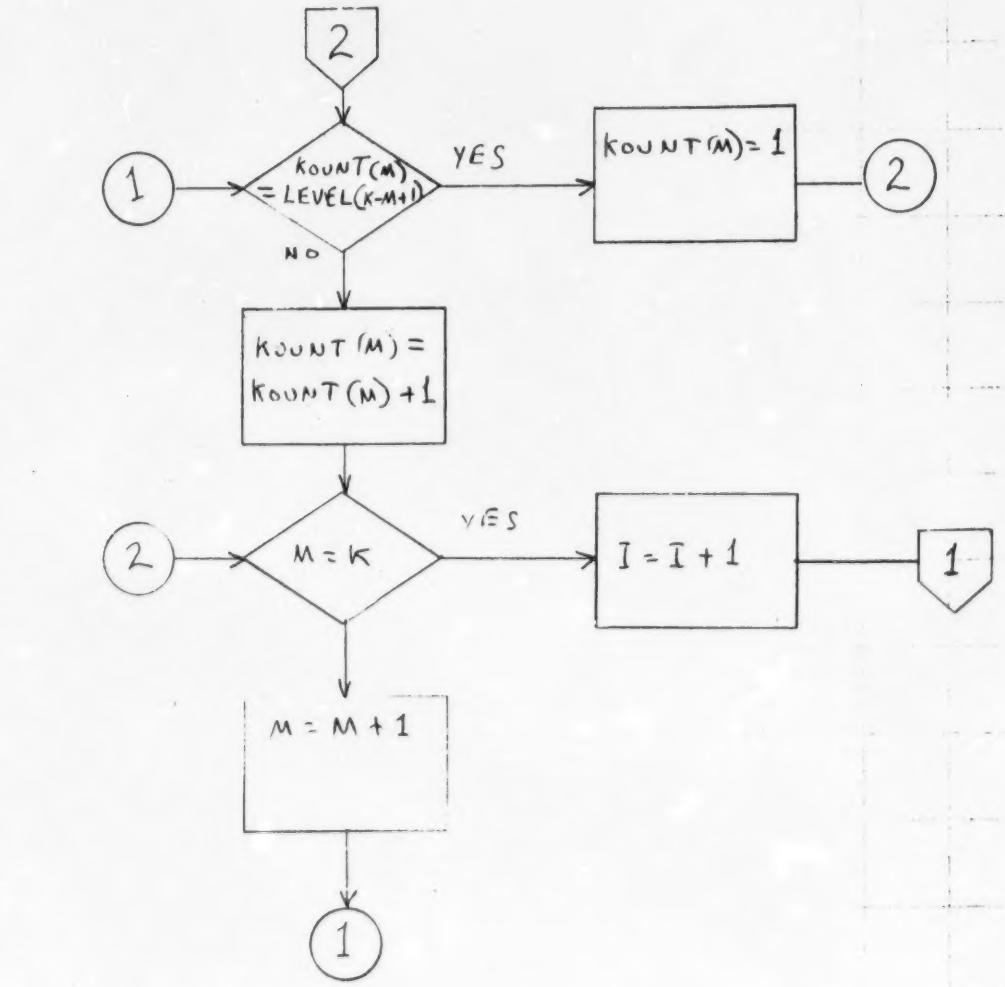


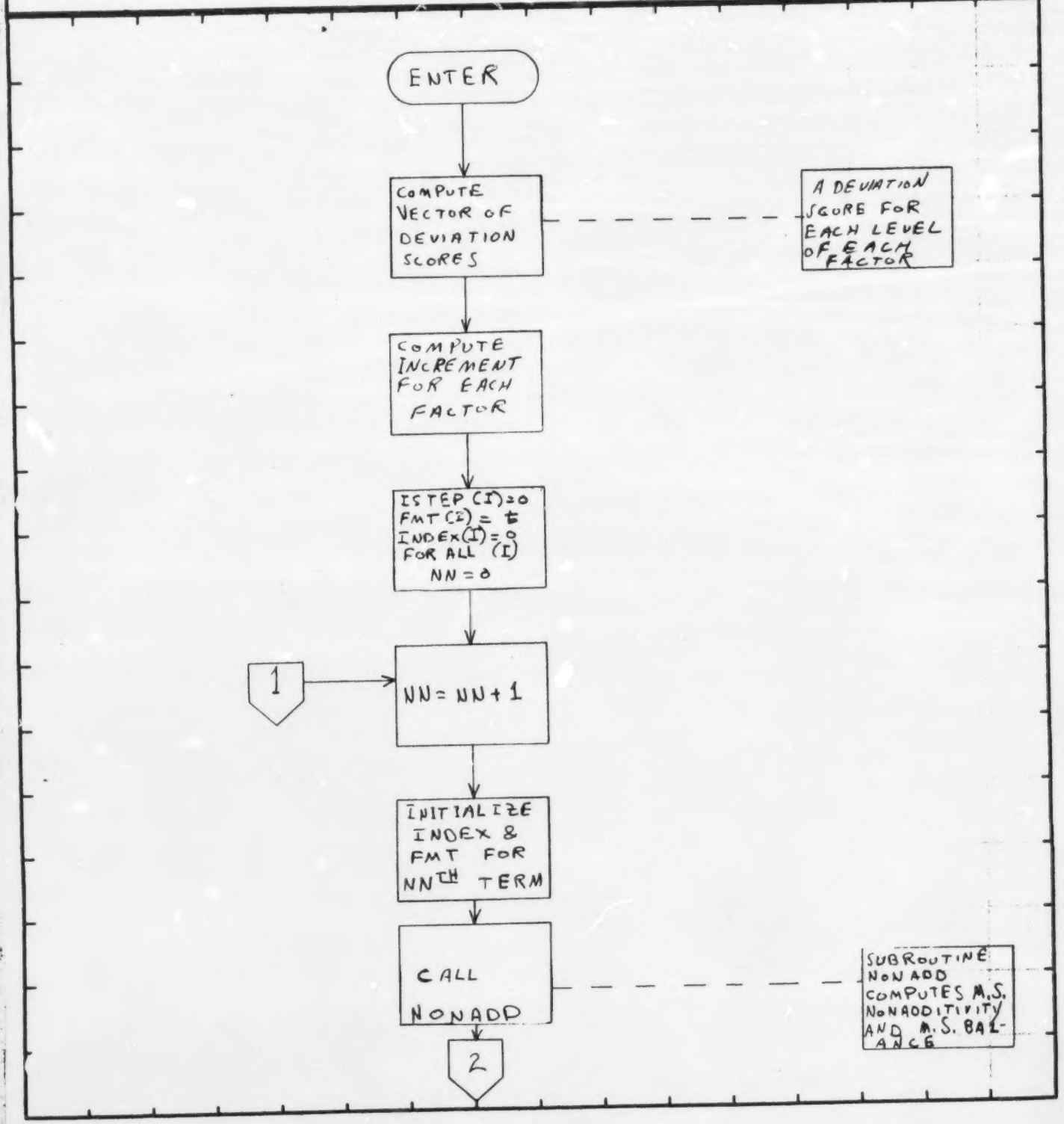
Project Leader _____ System/Job/Program Name ARRNG

Prepared By _____ Date 1 1 Page 2 of 2



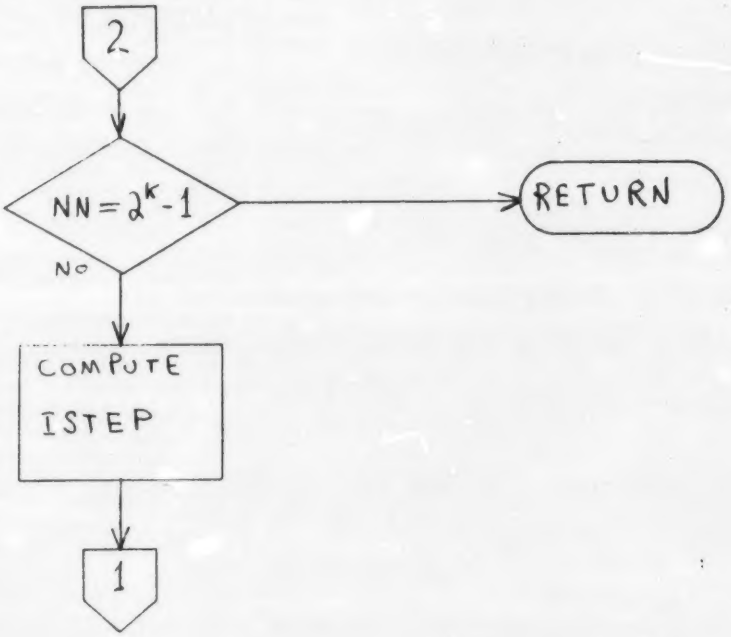
. roject Leader _____ System/Job/Program Name TUKEY

Prepared By _____ Date 1 1 Page 1 of 2


ENTER
COMPUTE VECTOR OF DEVIATION SCORES
A DEVIATION SCORE FOR EACH LEVEL OF EACH FACTOR
COMPUTE INCREMENT FOR EACH FACTOR
ISTEP (I) = 0
FMT (I) = 6
INDEX (I) = 0
FOR ALL (I)
NN = 0
1
NN = NN + 1
INITIALIZE INDEX & FMT FOR NN TH TERM
CALL NONADD
SUBROUTINE NONADD COMPUTES M.S. NONADDITIVITY AND M.S. BALANCE
2

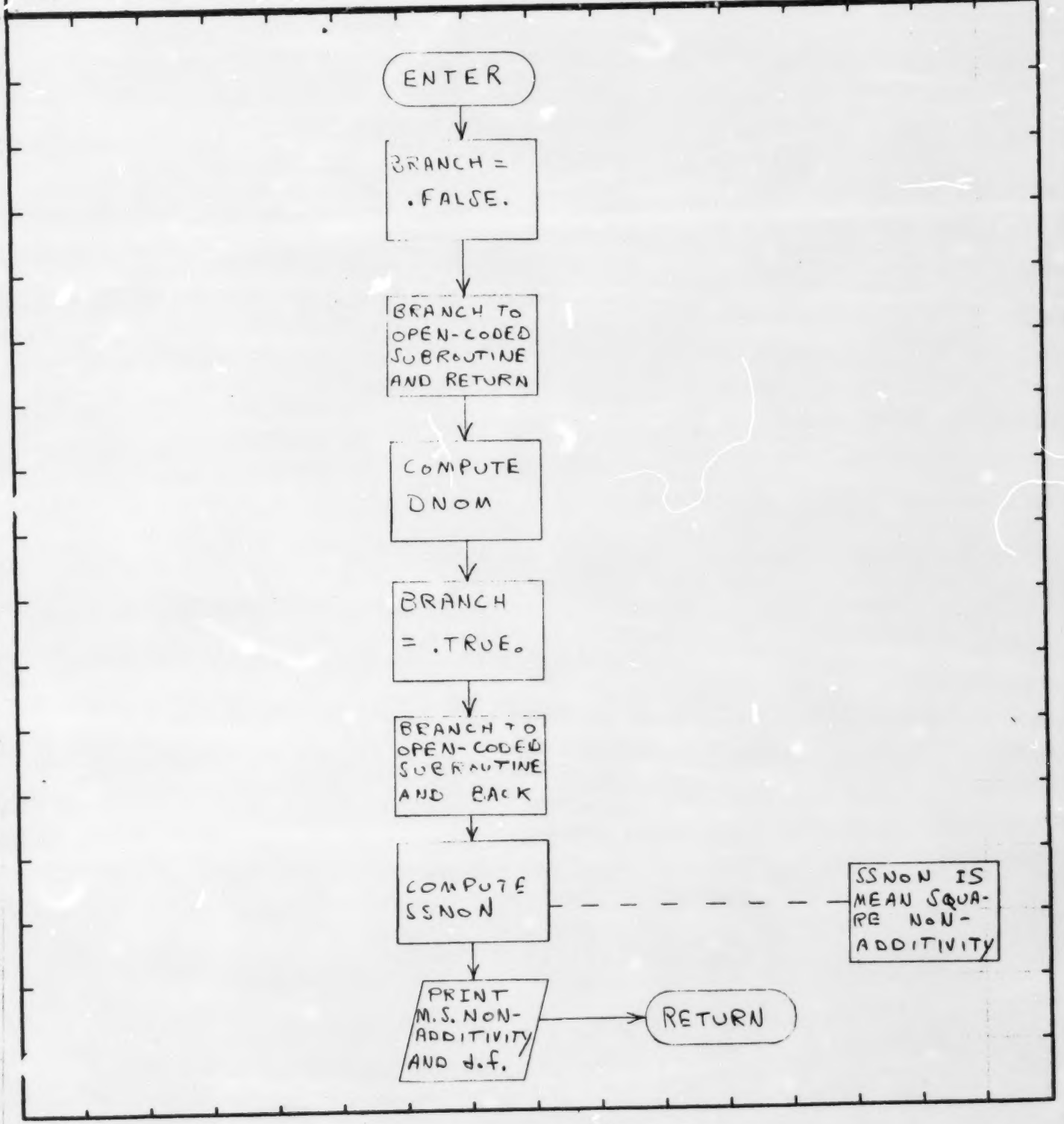
roject Leader _____ System/Job/Program Name TUKEY

Prepared By _____ Date 1 1 Page 2 of 2



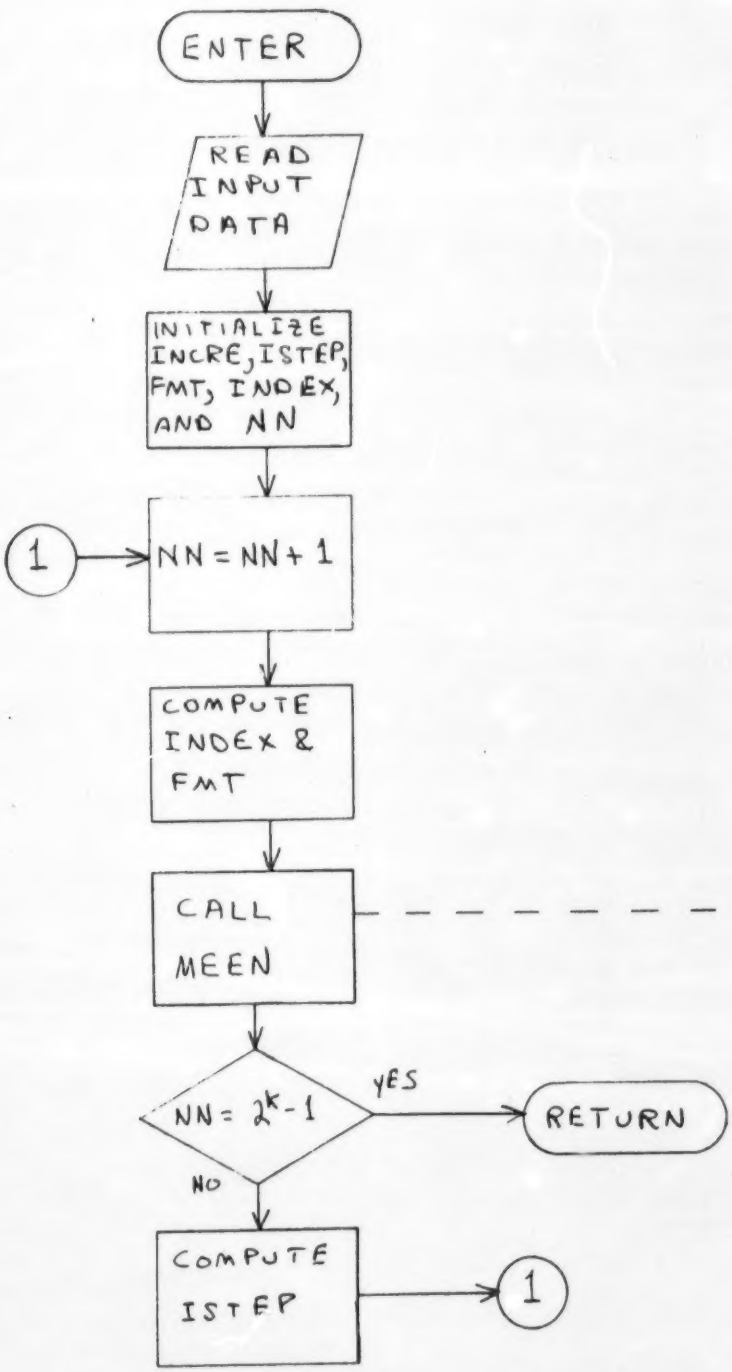
. roject Leader _____ System/Job/Program Name NONADD

Prepared By _____ Date / / Page 1 of 1



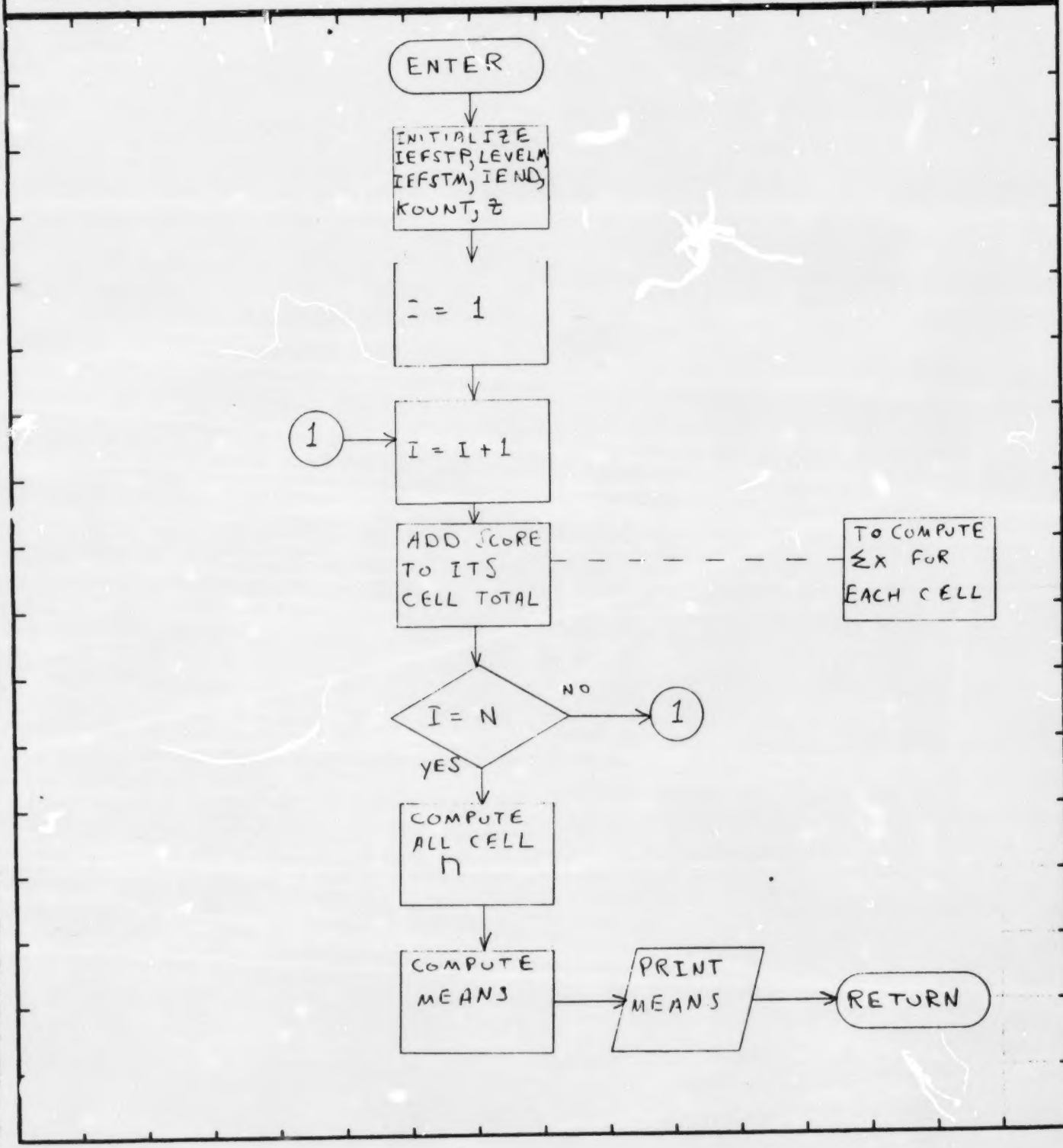
roject Leader _____ System/Job/Program Name PRTMN

Prepared By _____ Date / / Page 1 of 1



Project Leader _____ System/Job/Program Name MEEN

Prepared By _____ Date / / Page 1 of 1



```
C         7.   PROGRAM LISTING                    AS OF 09/09/75
C-------------------------------------------------------------------00001
C                                                                   00002
C                                                                   00003
C     PROGRAM AOVN1                                                 00004
C     MULTIFACTOR  ANALYSIS OF VARIANCE FOR N = 1 IN ALL CELLS      00005
C     WRITTEN BY DAVE TRITCHLER FOR DR. D.T. PEDRINI                00006
C     UNIVERSITY OF NEBRASKA AT OMAHA,1973                          00007
C                                                                   00008
C-------------------------------------------------------------------00009
C                                                                   00010
C-------------------------------------------------------------------00011
C     MAXIMUM # OF FACTORS IS 8                                     00012
C     PERFORMS TUKEY'S TEST FOR NONADDITIVITY ON ALL INTERACTIONS USED 00013
C     AS ESTIMATES OF ERROR VARIANCE                                00014
C                                                                   00015
C   GMEAN = GRAND MEAN                                              00016
C   IFAC  = # OF NON-REPEATED MEASURE FACTORS                       00017
C   IFACR = # OF REPEATED MEASURE FACTORS                           00018
C   IFACP = INDEX OF LEVEL OF FIRST REPEATED MEASURE FACTOR         00019
C   K = TOTAL # OF FACTORS                                          00020
C-------------------------------------------------------------------00021
C                                                                   00022
      COMMON   X(3000),LEVEL(10),ISTEP(8),KOUNT(8),LAST(8),SUMSQ(255),00023
     1          NDF(255),SMEAN(255),ITITL(20),FMT(15),IFAC,IFACR,K,N,00024
     2          GMEAN,L,Y(3000),MSTEP(8),NSTEP(8)                   00025
      DIMENSION HEAD(8),FORM(20)                                    00026
      DIMENSION   IRVEC(128)                                        00027
      DATA HEAD/1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH/                    00028
      DATA NBLANK,NZERO/1H ,1H0/                                    00029
C                                                                   00030
C                                                                   00031
C        READ TITLE CARD                                            00032
  100 READ (5,1)ITITL                                               00033
C                                                                   00034
C        IF A 'THATSALL' CARD WAS READ, GO TO STOP                  00035
      DATA ITCON/4HTHAT/                                            00036
      IF(ITITL(1).EQ.ITCON) GO TO 500                               00037
C                                                                   00038
C        PRINT TITLE                                                00039
      PRINT 2,ITITL                                                 00040
C                                                                   00041
C        READ LEVELS CARD                                           00042
      READ (5,3)LEVEL                                               00043
C                                                                   00044
C        COUNT # OF NON-REPEATED MEASURE FACTORS                    00045
      DO 70 I=1,9                                                   00046
      IF(LEVEL(I))290,80,70                                         00047
   70 CONTINUE                                                      00048
   80 IFAC=I-1                                                      00049
C                                                                   00050
C        COUNT # OF REPEATED MEASURE FACTORS AND TOTAL # OF FACTORS 00051
      DO 120 M=I,9                                                  00052
  120 LEVEL(M)=LEVEL(M+1)                                           00053
      DO 90 J=I,9                                                   00054
      IF(LEVEL(J)) 290,110,90                                       00055
   90 CONTINUE                                                      00056
  110 K=J-1                                                         00057
      IFACR=K-IFAC                                                  00058
C                                                                   00059
      IFACP=IFAC+1                                                  00060
      IF(K.GT.8) GO TO 290
```

```
      ISPACE = NBLANK                                                   00061
                                                                        00062
C                                                                       00063
C        PRINT LEVELS OF NON-REPEATED MEASURE FACTORS                   00064
      PRINT 4,(HEAD(I),LEVEL(I),I=1,IFAC)                               00065
      IF(IFACR.LE.0) GO TO 130                                          00066
C                                                                       00067
C        PRINT LEVELS OF REPEATED MEASURE FACTORS                       00068
      PRINT 5,(HEAD(I),LEVEL(I),I=IFACP,K)                              00069
C                                                                       00070
C        COMPUTE TOTAL # OF DATA POINTS(CELLS)                          00071
  130 N=LEVEL(1)                                                        00072
      DO 101 I=2,K                                                      00073
  101 N=N*LEVEL(I)                                                      00074
C                                                                       00075
C        READ DATA FORMAT                                               00076
      READ (5,1) FORM                                                   00077
C                                                                       00078
      READ (5,FORM) (Y(I),I=1,N)                                        00079
C                                                                       00080
C                                                                       00081
C                                                                       00082
C        DETERMINE THAT PROBLEM DOES NOT EXCEED AVAILABLE STORAGE       00083
      M=LEVEL(1)+1                                                      00084
      DO 105 I=2,K                                                      00085
  105 M=M*(LEVEL(I)+1)                                                  00086
      IF(M.GT.3000) GO TO 290                                           00087
C                                                                       00088
C                                                                       00089
C---------------------------------------------------------------------- 00090
C        THESE SUBROUTINES DO THE ANALYSIS                              00091
C      AVCAL AND MEANQ ARE LINKED FROM IBM'S SSP                        00092
C                                                                       00093
      CALL ARRNG                                                        00094
      CALL AVCAL(K,LEVEL,X,L,ISTEP,LAST)                                00095
      CALL MEANQ(K,LEVEL,X,GMEAN,SUMSQ,NDF,SMEAN,MSTEP,KOUNT,LAST)      00096
C---------------------------------------------------------------------- 00097
C                                                                       00098
C                                                                       00099
      PRINT 7,GMEAN                                                     00100
      PRINT 8                                                           00101
C                                                                       00102
C                                                                       00103
C---------------------------------------------------------------------- 00104
C        PRINT RESULTS FOR NON-REPEATED MEASURE FACTORS                 00105
C                                                                       00106
        IRINC = 1                                                       00107
      LL=(2**IFAC)-1                                                    00108
      ISTEP(1)=1                                                        00109
      DO 106 I=2,K                                                      00110
  106 ISTEP(I)=0                                                        00111
      DATA BLANK/4H    /                                                00112
      DO 107 I=1,15                                                     00113
  107 FMT(I)=BLANK                                                      00114
      NN=0                                                              00115
      SUM=0.0                                                           00116
  122 NN=NN+1                                                           00117
      L=0                                                               00118
      DO 140 I=1,IFAC                                                   00119
      FMT(I)=BLANK                                                      00120
      IF(ISTEP(I)) 132,140,132                                          00121
  132 L=L+1                                                             00122
      FMT(L)=HEAD(I)
```

```
  140 CONTINUE                                                          00123
      IF(NN .EQ. LL) GO TO 301                                          00124
      F = SMEAN(NN) / SMEAN(LL)                                         00125
      P = PROBF( NDF(NN) , NDF(LL) , F )                                00126
      PRINT 9, ISPACE ,                                                 00127
     1          (FMT(I),I=1,15) , SUMSQ(NN) , NDF(NN) , SMEAN(NN) , F , P00128
      GO TO 302                                                         00129
  301 PRINT 9, ISPACE ,                                                 00130
     1          (FMT(I),I=1,15) , SUMSQ(NN) , NDF(NN) , SMEAN(NN)      00131
        IRVEC(  IR(NC)*= NN                                             00132
        IRINC =   IRINC + 1                                             00133
  302 SUM=SUM+SUMSQ(NN)                                                 00134
      IF(NN-LL) 145,170,170                                             00135
  145 DO 160 I=1,IFAC                                                   00136
      IF(ISTEP(I)) 147,150,147                                          00137
  147 ISTEP(I)=0                                                        00138
      GO TO 160                                                         00139
  150 ISTEP(I)=1                                                        00140
      GO TO 122                                                         00141
  160 CONTINUE                                                          00142
C                                                                       00143
C         CHECK FOR REPEATED MEASURES                                   00144
C                                                                       00145
  170 IF(IFACR .NE. 0) GO TO 300                                        00146
      N=N-1                                                             00147
C                                                                       00148
C         PRINT TOTAL SUM OF SQUARES                                    00149
C                                                                       00150
      PRINT 10,SUM,N                                                    00151
      GO TO 280                                                         00152
C-----------------------------------------------------------------------00153
C                                                                       00154
C-----------------------------------------------------------------------00155
C         PRINT RESULTS FOR REPEATED MEASURE FACTORS                    00156
  300 CONTINUE                                                          00157
      PRINT 11                                                          00158
      IERR = NN                                                         00159
      IENC = LL + 1                                                     00160
      IERR = NN + IENC                                                  00161
      IFACR=0                                                           00162
      DO 497 I=1,IFAC                                                   00163
  497 ISTEP(I)=0                                                        00164
      ISTEP(IFACP)=1                                                    00165
      LL=(2**K)-1                                                       00166
  162 NN=NN+1                                                           00167
      L=0                                                               00168
      DO 180 I=1,K                                                      00169
      FMT(I)=BLANK                                                      00170
      IF(ISTEP(I)) 172,180,172                                          00171
  172 L=L+1                                                             00172
      FMT(L)=HEAD(I)                                                    00173
  180 CONTINUE                                                          00174
      IF ( NN .EQ. IERR ) GO TO 303                                     00175
      F = SMEAN(NN) / SMEAN(IERR)                                       00176
      P = PROBF( NDF(NN) , NDF(IERR) , F )                              00177
      PRINT 9, ISPACE ,                                                 00178
     1          (FMT(I),I=1,15) , SUMSQ(NN) , NDF(NN) , SMEAN(NN) , F , P00179
      ISPACE = NBLANK                                                   00180
      GO TO 304                                                         00181
  303 PRINT 9, ISPACE ,                                                 00182
     1          (FMT(I),I=1,15) , SUMSQ(NN) , NDF(NN) , SMEAN(NN)      00183
      ISPACE = NZERO                                                    00184
      IERR = IERR + IENC
```

```
      IRVEC(  IRINC) = NN                                                00185
      IRINC =   IRINC + 1                                                00186
  304 SUM=SUM+SUMSQ(NN)                                                  00187
      IF(NN-LL) 185,170,170                                              00188
  185 DO 200 I=1,K                                                       00189
      IF(ISTEP(I)) 187,190,187                                           00190
  187 ISTEP(I)=0                                                         00191
      GO TO 200                                                          00192
  190 ISTEP(I)=1                                                         00193
      GO TO 162                                                          00194
  200 CONTINUE                                                           00195
  270 GO TO 170                                                          00196
C-------------------------------------------------------------------------00197
C                                                                        00198
C                                                                        00199
C                                                                        00200
  280 CALL TUKEY(IRVEC)                                                  00201
      CALL PRTMN                                                         00202
      GO TO 100                                                          00203
  290 PRINT 12                                                           00204
  500 STOP                                                               00205
C                                                                        00206
C                                                                        00207
    1 FORMAT(20A4)                                                       00208
    2 FORMAT (26H1ANALYSIS OF VARIANCE----- , 20A4 //)                   00209
    3 FORMAT(10I3)                                                       00210
    4 FORMAT (18H LEVELS OF FACTORS / (3X, A1, 7X, I4))                  00211
    5 FORMAT (18H REPEATED MEASURES / (3X, A1, 7X, I4))                  00212
    7 FORMAT (1H0 // 12H GRAND MEAN , F20.5 ////)                        00213
    8 FORMAT(10HOSOURCE OF18X,7HSUMS OF10X,10HDEGREES OF9X,4HMEAN/10H VA00214
     1RIATION 18X, 7HSQUARES 11X, 7HFREEDOM 10X, 7HSQUARES, 17X,         00215
     2 1HF , 20X, 1HP /)                                                 00216
    9 FORMAT(A1,15A1,F20.5, 9X,I6,F20.5,2X,F20.5,F20.5)                  00217
   10 FORMAT (6HOTOTAL , 10X, F20.5, 10X, I6)                            00218
   11 FORMAT (18HOREPEATED MEASURES )                                    00219
   12 FORMAT (28H IMPROPER PROBLEM DEFINITION )                          00220
C                                                                        00221
C                                                                        00222
      END                                                                00223
      SUBROUTINE  APRNG                                                  00224
C-------------------------------------------------------------------------00225
C                                                                        00226
C        ARRANGE DATA PROPERLY FOR SUCCEEDING ANALYSIS.                  00227
C                                                                        00228
C        K = TOTAL # OF FACTORS.                                         00229
C        LEVEL(I) = LEVELS OF FACTOR I.                                  00230
C        N = TOTAL # OF DATA POINTS.                                     00231
C        X = VECTOR OF ARRANGED DATA.                                    00232
C        Y = DATA BEFORE ARRANGEMENT.                                    00233
C        ISTEP(I) = INCREMENT IN VECTOR X USED TO LOCATE DATA FOR        00234
C        FACTOR I.                                                       00235
C-------------------------------------------------------------------------00236
C                                                                        00237
C                                                                        00238
      COMMON   X(3000),LEVEL(10),ISTEP(8),KOUNT(8),LAST(8),SUMSQ(255),   00239
     1          NDF(255),SMEAN(255),ITITL(20),FMT(15),IFAC,IFACR,K,N,    00240
     2          GMEAN,L,Y(3000),MSTEP(8),NSTEP(8)                        00241
C                                                                        00242
C                                                                        00243
C        CALCULATE ISTEP.                                                00244
      ISTEP(K)=1                                                         00245
      KM1=K-1                                                            00246
      DO 110 J=1,KM1
```

```
      I=K-J                                                              00247
      M=I+1                                                              00248
  110 ISTEP(I)=ISTEP(M)*(LEVEL(J)+1)                                     00249
C                                                                        00250
C        INITIALIZE KOUNT.                                               00251
      DO 115 I=1,K                                                       00252
  115 KOUNT(I)=1                                                         00253
C                                                                        00254
C                                                                        00255
      DO 135 I=1,N                                                       00256
      L=KOUNT(K)                                                         00257
      DO 120 J1=2,K                                                      00258
      J=J1-1                                                             00259
C        CALCULATE POSITION L.                                           00260
  120 L=L+ISTEP(J)*(KOUNT(J)-1)                                          00261
C        MOVE DATA POINT I TO POSITION Y(L).                             00262
      X(L)=Y(I)                                                          00263
C                                                                        00264
C        INCREMENT KOUNT.                                                00265
      DO  130 M=1,K                                                      00266
      J=K-M+1                                                            00267
      IF(KOUNT(M)-LEVEL(J)) 124,125,124                                  00268
  124 KOUNT(M)=KOUNT(M)+1                                                00269
      GO TO 135                                                          00270
  125 KOUNT(M)=1                                                         00271
  130 CONTINUE                                                           00272
  135 CONTINUE                                                           00273
      IREV=K/2                                                           00274
      DO 140 I=1,IREV                                                    00275
      IZOT=ISTEP(I)                                                      00276
      ISTEP(I)=ISTEP(K-I+1)                                              00277
  140 ISTEP(K-I+1)=IZOT                                                  00278
      DO 150 I=1,K                                                       00279
  150 NSTEP(I)=ISTEP(I)                                                  00280
      RETURN                                                             00281
      END                                                                00282
      SUBROUTINE TUKEY(  IRVEC)                                          00283
C                                                                        00284
C--------------------------------------------------------------------    00285
C                                                                        00286
C        THIS IS A DRIVER FOR THE SUBROUTINE NONADD WHICH IS USED TO     00287
C        COMPUTE TUKEY'S TEST FOR NONADDITIVITY                          00288
C                                                                        00289
C        X = VECTOR OF DEVIATION SCORES PREPARED BY SUBROUTINE DEVS.     00290
C        AIVEC = VECTOR OF DEVIATION SCORES TO BE PREPARED.              00291
C        INCRE(I) = INCREMENT IN VECTOR Y USED TO LOCATE DATA FOR        00292
C        FACTOR I.                                                       00293
C        MINC(I) = STARTING POSITION IN AIVEC FOR FACTOR I.              00294
C--------------------------------------------------------------------    00295
      COMMON     X(3000),LEVEL(10),ISTEP(8),KOUNT(8),LAST(8),SUMSQ(255), 00296
     1            NDF(255),SMEAN(255),ITITL(20),FMT(15),IFAC,IFACR,K,N,  00297
     2           GMEAN,L,Y(3000),MSTEP(8),NSTEP(8)                       00298
      DIMENSION INCRE(8),INDEX(8),AIVEC(100),MINC(8),HEAD(8)             00299
      DIMENSION   IRVEC(128)                                             00300
      DATA HEAD/1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH/                         00301
C                                                                        00302
      PRINT 8                                                            00303
C                                                                        00304
C     FIND END OF ARRAY                                                  00305
      IEND=NSTEP(K)*(LEVEL(K)+1)                                         00306
C                                                                        00307
C     FIND TOTAL N                                                       00308
```

```
      N=N+1                                                              00309
                                                                         00310
C                                                                        00311
C        COMPUTE MINC(I) = STARTING POSITION IN AIVEC FOR FACTOR I.      00312
      MINC(1)=0                                                          00313
      DO 12 I=2,K                                                        00314
   12 MINC(I)=MINC(I-1)+LEVEL(I-1)                                       00315
C                                                                        00316
C        COMPUTE AIVEC.IT WILL CONSIST OF DEVIATIONS FOR THE LEVELS OF   00317
C        FACTOR 1,THE LEVELS OF FACTOR 2,ETC.                            00318
      DO 13 I=1,K                                                        00319
      KIN=LEVEL(I)                                                       00320
      DO 13 J=1,KIN                                                      00321
      J2=IEND-J*NSTEP(I)                                                 00322
      L=MINC(I)+LEVEL(I)-J+1                                             00323
   13 AIVEC(L)=X(J2)/N                                                   00324
C                                                                        00325
C        FIND INCREMENT IN INPUT DATA VECTOR                             00326
      INCRE(K)=1                                                         00327
      KM1=K-1                                                            00328
      DO 14 J=1,KM1                                                      00329
      I=K-J                                                              00330
      M=I+1                                                              00331
   14 INCRE(I)=INCRE(M)*LEVEL(M)                                         00332
C                                                                        00333
C        INITIALIZE                                                      00334
      LL=(2**K)-1                                                        00335
      ISTEP(1)=1                                                         00336
      DO 106 I=2,K                                                       00337
  106 ISTEP(I)=0                                                         00338
      DATA BLANK/4H    /                                                 00339
      DO 107 I=1,15                                                      00340
  107 FMT(I)=BLANK                                                       00341
      DO 108 I=1,8                                                       00342
  108 INDEX(I)=0                                                         00343
      NN=0                                                               00344
      JA = 1                                                             00345
C                                                                        00346
C                                                                        00347
C--------------------------------------------------------------------    00348
C        LOOP THROUGH CALL TO NONADD.EACH CALL IS FOR ONE  INTERACTION.  00349
  122 NN=NN+1                                                            00350
      LA=0                                                               00351
      DO 140 I=1,K                                                       00352
      INDEX(I)=0                                                         00353
      FMT(I)=BLANK                                                       00354
      IF(ISTEP(I)) 132,140,132                                           00355
  132 LA=LA+1                                                            00356
      FMT(LA)=HEAD(I)                                                    00357
      INDEX(I)=1                                                         00358
  140 CONTINUE                                                           00359
      ICNT=0                                                             00360
      DO 37 IK=1,K                                                       00361
   37 ICNT=ICNT+INDEX(IK)                                                00362
      IF(  IRVEC(JA) .NE. NN) GO TO 39                                   00363
      JA = JA + 1                                                        00364
      IF(NN .LT. 2) GO TO 39                                             00365
      CALL NONADD(INCRE,INDEX,AIVEC,MINC,NN)                             00366
   39 IF(NN-LL) 145,300,300                                              00367
  145 DO 160 I=1,K                                                       00368
      IF(ISTEP(I)) 147,150,147                                           00369
  147 ISTEP(I)=0                                                         00370
      GO TO 160
```

```
  150 ISTEP(I)=1                                                        00371
      GO TO 122                                                         00372
  160 CONTINUE                                                          00373
C-----------------------------------------------------------------------00374
C                                                                       00375
  300 RETURN                                                            00376
C                                                                       00377
C                                                                       00378
    8 FORMAT(//12HOINTERACTION,15X,  9HMS NONADD , 12X, 10HMS BALANCE , 00379
     1 12X, 4HD.F. , 18X, 1HF, 19X, 1HP, / )                            00380
C                                                                       00381
      END                                                               00382
      SUBROUTINE NONADD(INCRE,INDEX,AIVEC,MINC,NN)                      00383
C                                                                       00384
C-----------------------------------------------------------------------00385
C                                                                       00386
C         COMPUTE M.S. NONADDITIVITY AND M.S. BALANCE.                  00387
C                                                                       00388
C         Z = VECTOR WITH INPUT DATA.                                   00389
C         W = WORK VECTOR.                                              00390
C         AIVEC = VECTOR OF DEVIATIONS PREPARED BY SUBROUTINE TUKEY.    00391
C         MINC(I) = STARTING POSITION IN AIVEC FOR FACTOR I.            00392
C-----------------------------------------------------------------------00393
C                                                                       00394
      COMMON     W(3000),LEVEL(10),ISTEP(8),KOUNT(8),LAST(8),SUMSQ(255), 00395
     1            NDF(255),SMEAN(255),ITITL(20),FMT(15),IFAC,IFACR,K,N,  00396
     2           GMEAN,L,Z(3000),MSTEP(8),NSTEP(8)                      00397
      DIMENSION INCRE(8),INDEX(8),AIVEC(100),MINC(8)                    00398
      LOGICAL BRANCH                                                    00399
C                                                                       00400
C                                                                       00401
C-----------------------------------------------------------------------00402
C         COMPUTE    MEAN SQUARE  NONADDITIVITY.                        00403
C                                                                       00404
      BRANCH = .FALSE.                                                  00405
      GO TO 60                                                          00406
   65 DNOM = 0.                                                         00407
      DO 40 I=1,N                                                       00408
   40 DNOM=DNOM+(W(I)*W(I))                                             00409
      BRANCH = .TRUE.                                                   00410
      GO TO 60                                                          00411
   70 SSNON = 0.                                                        00412
      DO 41 I = 1, N                                                    00413
   41 SSNON = SSNON + W(I)                                              00414
      SSNON=SSNON*SSNON                                                 00415
      SSNON=SSNON/DNOM                                                  00416
C-----------------------------------------------------------------------00417
C                                                                       00418
C                                                                       00419
C-----------------------------------------------------------------------00420
C         COMPUTE    MEAN SQUARE  BALANCE.                              00421
C                                                                       00422
      COLAPS = 1.                                                       00423
      DO 50 I=1,K                                                       00424
   50 IF(INDEX(I) .EQ. 0) COLAPS = COLAPS * LEVEL(I)                    00425
      XMSBAL = SUMSQ(NN) * COLAPS - SSNON                               00426
      NNDF = NDF(NN) - 1                                                00427
      IF ( NNDF .EQ. 0 ) GO TO 12                                       00428
      XMSBAL = XMSBAL / NNDF                                            00429
C-----------------------------------------------------------------------00430
C                                                                       00431
C                                                                       00432
```

```
      IF ( XMSBAL .LT. .0001 ) GO TO 13                                 00433
      F = SSNON / XMSBAL                                                00434
      P = PRBF( 1, NNDF, F )                                            00435
      PRINT 9,(FMT(I),I=1,15),SSNON,XMSBAL,NNDF,F,P                     00436
      GO TO 14                                                          00437
   12 PRINT 10,FMT,SSNON,NNDF                                           00438
      GO TO 14                                                          00439
   13 PRINT 11, FMT, SSNON, XMSBAL, NNDF                                00440
   14 RETURN                                                            00441
C                                                                       00442
C-----------------------------------------------------------------------00443
C                                                                       00444
C         OPEN-CODED SUBROUTINE.                                        00445
C                                                                       00446
   60 DO 17 I=1,K                                                       00447
   17 KOUNT(I)=1                                                        00448
      DO  35 I=1,N                                                      00449
      L=KOUNT(K)                                                        00450
      J1=K-1                                                            00451
      DO 20 J=1,J1                                                      00452
   20 L=L+INCRE(J)*(KOUNT(J)-1)                                         00453
      W(L)=1.0                                                          00454
      IF(BRANCH) W(L) = Z(L)                                            00455
      DO 21 J2=1,K                                                      00456
      J3=MINC(J2)+KOUNT(J2)                                             00457
      IF(INDEX(J2).EQ.1)GO TO 22                                        00458
      IF(BRANCH) GO TO 21                                               00459
      IF(KOUNT(J2).NE.1) W(L)=0.                                        00460
      GO TO 21                                                          00461
   22 W(L)=W(L)*AIVEC(J3)                                               00462
   21 CONTINUE                                                          00463
      DO 30 M=1,K                                                       00464
      IF(KOUNT(M)-LEVEL(M)) 24,25,24                                    00465
   24 KOUNT(M)=KOUNT(M)+1                                               00466
      GO TO 35                                                          00467
   25 KOUNT(M)=1                                                        00468
   30 CONTINUE                                                          00469
   35 CONTINUE                                                          00470
      IF(BRANCH) GO TO 70                                               00471
      GO TO 65                                                          00472
C-----------------------------------------------------------------------00473
C                                                                       00474
C                                                                       00475
C                                                                       00476
    9 FORMAT(1X, 15A1, F20.5, 2X, F20.5, 9X, 5H(1)/( , I4, 1H) , 1X,    00477
     1 2F20.5)                                                          00478
   10 FORMAT(1X, 15A1, F20.5, 31X, 5H(1)/( , I4, 1H) )                  00479
   11 FORMAT(1X, 15A1, F20.5, 2X, F20.5, 9X, 5H(1)/( , I4, 1H) )        00480
C                                                                       00481
      END                                                               00482
      SUBROUTINE PRTMN                                                  00483
C-----------------------------------------------------------------------00484
C-----------------------------------------------------------------------00485
C                                                                       00486
C         THIS IS A DRIVER FOR THE SUBROUTINE WHICH COMPUTES AND PRINTS 00487
C         MEANS FOR EACH TERM.                                          00488
C                                                                       00489
C         INCRE(I) = INCREMENT USED TO LOCATE DATA FOR FACTOR I IN      00490
C         FMT IS ALPHA VECTOR - LABEL FOR TERM.                         00491
C-----------------------------------------------------------------------00492
C                                                                       00493
      OCOMMON     X(3000),LEVEL(10),ISTEP(8),KOUNT(8),LAST(8),SUMSQ(255),00494
     1            NDF(255),SMEAN(255),ITITL(20),FMT(15),IFAC,IFACR,K,N,
```

```
     2          GMEAN,L,Y(3000),MSTEP(8),NSTEP(8)                    00495
      DIMENSION  INCRE(8),INDEX(8),HEAD(8)                           00496
      DATA HEAD/1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH/                     00497
C                                                                    00498
C                                                                    00499
      PRINT 8                                                        00500
C                                                                    00501
C        FIND INCREMENT IN NATURAL DATA VECTOR                       00502
C        VECTOR Y.                                                   00503
      INCRE(K)=1                                                     00504
      KM1=K-1                                                        00505
      DO 14 J=1,KM1                                                  00506
      I=K-J                                                          00507
      M=I+1                                                          00508
   14 INCRE(I)=INCRE(M)*LEVEL(M)                                     00509
      LL=(2**K)-1                                                    00510
      ISTEP(1)=1                                                     00511
      DO 106 I=2,K                                                   00512
  106 ISTEP(I)=0                                                     00513
C                                                                    00514
      DATA BLANK/4H    /                                           00515
      DO 107 I=1,15                                                  00516
  107 FMT(I)=BLANK                                                   00517
      DO 108 I = 1, K                                                00518
  108 INDEX(I)=0                                                     00519
      NN = 0                                                         00520
  122 NN = NN + 1                                                    00521
      LA = 0                                                         00522
      DO 140 I= 1, K                                                 00523
      INDEX(I) = 0                                                   00524
      FMT(I) = BLANK                                                 00525
      IF ( ISTEP(I) ) 132, 140, 132                                  00526
  132 LA = LA + 1                                                    00527
      FMT(LA) = HEAD(I)                                              00528
      INDEX(I) = 1                                                   00529
  140 CONTINUE                                                       00530
      CALL MEEN( INCRE, INDEX)                                       00531
   39 IF ( NN - LL ) 145, 300, 300                                   00532
  145 DO 160 I = 1, K                                                00533
      IF ( ISTEP(I) ) 147, 150, 147                                  00534
  147 ISTEP(I) = 0                                                   00535
      GO TO 160                                                      00536
  150 ISTEP(I) = 1                                                   00537
      GO TO 122                                                      00538
  160 CONTINUE                                                       00539
  300 RETURN                                                         00540
C                                                                    00541
C                                                                    00542
    8 FORMAT (//22HOMEANS FOR ALL EFFECTS     )                      00543
C                                                                    00544
      END                                                            00545
      SUBROUTINE MEEN( INCRE, INDEX )                                00546
C                                                                    00547
C----------------------------------------------------------------------00548
C                                                                    00549
C        COMPUTE MEAN.                                               00550
C                                                                    00551
C        INCRE(I) = INCREMENT USED TO LOCATE DATA FOR FACTOR I IN    00552
C        VECTOR Y.                                                   00553
C        Y = VECTOR OF INPUT DATA.                                   00554
C        Z = WORK VECTOR.                                            00555
C        IEND = END OF DATA FOR THIS TERM                            00556
```

```
C-----------------------------------------------------------------------00557
C                                                                       00558
C                                                                       00559
      OCOMMON   Z(3000), LEVEL(10), ISTEP(8), KOUNT(8), LAST(8),        00560
     1          SUMSQ(255), NDF(255), SMEAN(255), ITITL(20), FMT(15),    00561
     2          IFAC, IFACR, K, N, GMEAN, L, Y(3000), MSTEP(8), NSTEP(8) 00562
      DIMENSION INCRE(8), INDEX(8), IEFSTP(8)                           00563
C                                                                       00564
C                                                                       00565
      DO 1 J = 1, K                                                     00566
       IF ( INDEX(J) .EQ. 1 ) KEFF = J                                  00567
      I = K - J + 1                                                     00568
      IF ( INDEX(I)  .EQ. 1 ) KFIRST = I                                00569
    1  IEFSTP(J) = INDEX(J)                                             00570
      LEVELM = LEVEL(KEFF)                                              00571
      IEFSTM =1                                                         00572
      IF ( KEFF .LT. 2 ) GO TO 3                                        00573
      KDUM = KEFF - 1                                                   00574
      DO 2 J = 1, KDUM                                                  00575
       I = KEFF - J                                                     00576
       IF ( INDEX(I) .EQ. 0 ) GO TO 2                                   00577
       IEFSTP(I) = IEFSTM  * LEVELM                                     00578
       IEFSTM  = IEFSTP(I)                                              00579
       LEVELM = LEVEL(I)                                                00580
    2  CONTINUE                                                         00581
    3 IEND = IEFSTP(KFIRST) * LEVEL(KFIRST)                             00582
       DO 60 I = 1, IEND                                                00583
   60  Z(I) = 0.                                                        00584
      DO 17 I = 1, K                                                    00585
   17  KOUNT(I) = 1                                                     00586
      DO 35 I = 1, N                                                    00587
       L = KOUNT(K)                                                     00588
      J1 = K - 1                                                        00589
      DO 20 J = 1, J1                                                   00590
   20  L = L + INCRE(J) * ( KOUNT(J) - 1 )                              00591
       LEFF = KOUNT(KEFF)                                               00592
      IF ( KEFF .LT. 2 ) GO TO 51                                       00593
      J1 = KEFF - 1                                                     00594
      DO 50 J = 1, J1                                                   00595
   50  LEFF = LEFF + IEFSTP(J) * ( KOUNT(J) - 1 )                       00596
   51 CONTINUE                                                          00597
      Z(LEFF) = Z(LEFF) + Y(L)                                          00598
       DO 30 M = 1, K                                                   00599
       IF ( KOUNT(M) - LEVEL(M) ) 24, 25, 24                            00600
   24  KOUNT(M) = KOUNT(M) + 1                                          00601
       GO TO 35                                                         00602
   25  KOUNT(M) = 1                                                     00603
   30  CONTINUE                                                         00604
   35 CONTINUE                                                          00605
      ICOLAP  = 1                                                       00606
      DO 90 I = 1, K                                                    00607
   90 IF ( INDEX(I) .EQ. 0 ) ICOLAP  = ICOLAP  * LEVEL(I)               00608
      COLAPS = ICOLAP                                                   00609
      DO 91 I = 1, IEND                                                 00610
   91  Z(I) = Z(I) / COLAPS                                             00611
      PRINT 9, FMT                                                      00612
      PRINT 10,( Z(I), I = 1, IEND )                                    00613
      RETURN                                                            00614
C                                                                       00615
C                                                                       00616
    9 FORMAT(11HOMEANS FOR ,15A1)                                       00617
   10 FORMAT ( 15X,5F20.5)                                              00618
      END                                                               00619
```

8. SUBROUTINES

(a) ARRNG - arranges data properly for succeeding analysis.

(b) AVCAL - prepares deviation scores for input to subroutine MEANQ. This subroutine is from IBM's Scientific Subroutine Package(SSP).

(c) MEANQ - computes sums of squares, degrees of freedom and mean squares. MEANQ is also found in SSP.

(d) TUKEY - driver for subroutine NONADD.

(e) NONADD - computes mean square nonadditivity and mean square balance.

(f) PRTMN - driver for subroutine MEEN.

(g) MEEN - computes mean.

(h) PRBF - computes probatility of an F - ratio. The flow chart and program listing for this subroutine are not included. They may be obtained from Donald Veldman's book.

9. MEMORY REQUIREMENTS

In its present form, AOVN1 requires 68 hexadecimal K. It is dimensioned for 3000 data values, which could be reduced. Also non-essential subroutines such as PRBF could be deleted to save memory, if necesary.

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